SILVER LAKE OF MADISON

LAKE LAY MONITORING PROGRAM

1984

Freshwater Biology Group (FBG)

University of New Hampshire

Durham

by

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To obtain more information about the Lake Lay Monitoring Program (LLMP) please contact Dr. Baker at (603)-862-2060 or Dr. Haney at (603)-862-2100.

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ACKNOWLEDGMENTS

Silver Lake has been a part of the Lake Lay Monitoring Program (LLMP) since 1983. Through the efforts of Dr. Lawrence Slanetz and dedicated lay monitors, the program continued strongly in 1984. Lay monitors on Silver Lake included:

Team 1 -- Percy Hill, Charlotte Hill, A. Crosby Kennett, Frances Kennett, Adam Haybach

Team 2 -- Robert Benford, William Jones, Lawrence Slanetz

pH and alkalinity team -- Robert G. Newton, William Jones, Robert M. Newton

We congratulate the lay monitors on the quality of their work and anticipate that the monitors will continue their efforts next year. We wish to thank Dr. Slanetz and all the members ofthe Silver Lake Association for their time and effort. Also, we thank Robert Benford and Percy Hill for providing boats for our visiting team.

Members of our Freshwater Biology Group included Kim Babbitt, Matt Boyle, Chris Brown, Emily LeViness, Deb Thunberg, and Jennifer Turner. Kim was team leader, and was responsible for coordination of field trips and data analysis and interpretation. Matt was responsible for phosphorus analysis, Chris for chlorophyll a analysis, Emily for phytoplankton, and Deb for zooplankton. All team members helped with data organization and filing, and also with field trips throughout the summer. In the fall, Sara Hubner helped with report organization and word processing.

The Office of Computer Services kindly provided computer time and data storage space for the Lake Lay Monitoring program. The final text was set with Wordstar on Northstar and Zenith microcomputers, and printed on a letter-quality Spinwriter.

Brief Non-technical Summary

1) The water quality in Silver Lake is high (oligotrophic) based on water transparency (deep Secchi disk depth), and small amounts of algae (low chlorophyll a concentration).

2) The pH of near-surface waters was moderate, however the pH of water below 10 meters was low. Alkalinity values were very low. Silver Lake may be endangered by acid rain in the near future.

3) The water quality was "poorer" this year than in 1983. This may be due to year to year changes in weather conditions. More data are needed to determine if this represents a trend in decreasing water quality or if this is due to year to year changes in weather conditions

4) Bacteria samples collected on September 4, 1984 indicate that the sanitary water quality of the lake was excellent. No fecal bacteria were found in any of the samples collected.

Comments and Recommendations for Silver Lake 1984

1) The consistency of data collection by the lay monitors was excellent throughout the 1984 season. The data collected this year provided good seasonal and spatial coverage of the lake. Continued monitoring on this level will help to insure the early detection of changing lake water quality.

2) Data obtained by the FBG in 1983 and 1984 indicate that the dissolved water color in Silver Lake is relatively low. This is important to know, for water color decreases the water transparency, and thus the Secchi disk depth. A more accurate assessment of water quality in terms of Secchi disk depth can be made by knowing both the chlorophyll a concentration and the amount of dissolved water color, and with essentially no additional cost. To provide data on changes in water color throughout the season, we suggest that lay monitors collect samples for dissolved water color. This is especially important during the spring and early summer when precipitation, and thus inputs of humic acids, are likely to be highest. Details on the method for collection of dissolved water color samples will be provided on request.

3) Testing for pH and alkalinity should be emphasized at Silver Lake. It is especially important to obtain readings throughout the year, including the period of spring thaw, when pH depression is likely to occur.

4) The northern region of the lake appears to be more productive than other areas of the lake. Such "trophic gradients" within a lake may be a sign that the lake is undergoing a change in water quality. Sources of nutrients in the northern region of the lake should be more closely examined with an expanded phosphorus sampling program.

Executive Summary for Silver Lake 1984

1) Silver Lake is oligotrophic based on low chlorophyll a concentration (1.2 milligrams per cubic meter), high Secchi disk depth (5.4 meters) Phosphorus concentrations were low (3.5 micrograms per liter) at site 2 and moderate (17.7 micrograms per liter) at site 5. Based on phosphorus concentration site 2 would be considered oligotrophic and site 5 would be considered mesotrophic. The density of phytoplankton was low; 832 cells per milliliter at site 2 and 2092 cells per milliliter at site 5. The dominant groups of phytoplankton were the Chrysophytes and Chlorophytes. The Cryptomonads and Dinoflagellates were also of numerical importance at site 5. The species composition and concentration of phytoplankton also indicate oligotrophic conditions. The density of herbivorous zooplankton, dominated by calanoid copepods, was low (5 animals per liter) at site 2 and moderate (18 animals per liter) at site 5. Higher concentrations of phytoplankton and zooplankton at site 5 indicate higher productivity in that region.

2) The pH of near-surface water was moderate, 6.8-6.9. pH readings of 6.0 were found below 10 meters. pH values below 6.0 may limit the growth and distribution of cold-water fish. The alkalinity was extremely low, 1.9 milligrams calcium carbonate as measured by the FBG, and 1.5-5.0 milligrams as measured by the Silver Lake monitors. The low level of alkalinity indicates that Silver Lake has a low resistance against the effects of acid precipitation.

3) The dissolved oxygen concentration in the hypolimnion remained high (6-7 ppm) throughout the summer. These concentrations indicate oligotrophic conditions. High oxygen concentrations coupled with low hypolimnetic temperatures (8-9 degrees Celsius) make Silver Lake well-suited for cold-water fish.

4) The specific conductivity was low (30.6 micromhos/cm). Chloride ion concentration was also low 0.4 parts per million. These values indicate low inputs of road salt and/or raw sewage.

5) Bacteria samples taken on September 4, 1984 by Dr. L.W. Slanetz indicate that the sanitary quality of the water is excellent. No fecal coliform bacteria were found in any of the samples collected.

6) Total phosphorus concentrations were very low in samples collected from the major inlets streams, indicating low phosphorus loading from these sources. The average concentration was 5.4 micrograms per liter at Cooks Pond Brook and 5.0 micrograms per liter at Forest Brook.

7) The northern end of the lake appears to be more productive based on chlorophyll a, Secchi disk, phosphorus, phytoplankton and zooplankton data. The reasons for this are not clear, since phosphorus concentrations in the inlets streams in that area were lower than the concentration in the open water. Such trophic gradients" within a lake may be a sign that the lake is undergoing a change in water quality.

8) Based on Secchi disk depth and chlorophyll a concentration, the lakewater quality has decreased from 1983. The decrease may be due to year to year variations in weather conditions. More data is needed in order to determine if a trend is developing.

METHODS OF LAY MONITORS

Lay monitors collected data on four parameters: thermal stratification, water clarity, chlorophyll *a* concentration and total phosphorus. Data on thermal stratification, chlorophyll and Secchi disk depth were collected at weekly intervals whenever possible.

Thermal profiles were obtained by collecting lakewater samples at several depths with a modified Meyer bottle (Lind, 1979). Samples were obtained by lowering the empty but weighted bottle and sampling (by pulling out the stopper) at 1-meter intervals. The temperature of the samples was measured with Taylor pocket thermometers, and recorded in degrees Celsius.

Water clarity was measured while lowering an 8-inch (20 cm) Secchi disk and holding a view-scope just below the surface to eliminate the effects of surface reflection and wave-action. When the Secchi Disk disappeared the depth mark on the plastic suspension line was noted. The disk was raised until it just came into sight, and again the depth on the line was noted. The process was repeated two to three times, and an average between the two marks on the line (the point of disappearance and the point of re-appearance) was considered to be the Secchi Disk Depth (SDD), measured to the nearest one-tenth meter (0.1 meter) -- as for example, 5.2 meters. Readings were generally taken between 9 a.m. and 3 p.m., the period of maximum light penetration.

Chlorophyll *a* concentration was used as an estimator of algal biomass. A weighted tube 33 feet (10 meters) in length was used to collect an integrated water sample from the 'upper-lake' (epilimnion). The weighted end of the tube was slowly lowered to the interface of the epilimnion and the 'middle-lake' (metalimnion). The end of the tube was then bent double to shut off flow of air and water, and the weighted end of the tube (presently at the base of the epilimnion) was pulled up to the surface with a plastic line attached to it. The water in the tube (epilimnetic lakewater sample) was poured into a plastic bottle by placing the weighted end of the tube into the neck of the bottle and, while keeping the bent-off end above the weighted end, unbending the upper end (allowing the sample to discharge into the bottle).

Water samples were filtered through a membrane filter with a porosity of 0.45 microns. The damp filters containing chlorophyll-bearing algae were air dried for at least 15 minutes to prevent decomposition. Filtration and drying were done in the shade to minimize destruction (by bleaching) of chlorophyll. The dried filters were then sent to UNH for analysis. [In Durham, members of the Freshwater Biology Group extracted chlorophyll in 90% acetone saturated with magnesium carbonate, and read the absorbance of the sample at standard wavelengths (663 and 750 nanometers).]

Samples for total phosphorus were collected with a vertical 'tube' sampler in the same manner as chlorophyll a, or by dipping an acid-washed bottle in the water at the shallow inlet and outlet steams.

Total phosphorus samples were stored on ice in acid-washed 250 ml polyethylene bottles, and were fixed within 1 to 2 hours with 1.0 ml concentrated sulfuric acid. In Durham, the FBG members digested the total-phosphorus by adding ammonium persulfate and auto-claving the samples for at least 45 minutes. Finally, the phosphorus content of the samples was analyzed with the single-reagent method that included a fresh solution of ascorbic acid and potassium antimony tartrate (E.P.A., 1979). Absorbance of the blue phosphorus complex was measured spectrophotometrically at 650 nm.

METHODS OF FRESHWATER BIOLOGY GROUP (FBG) TEAM

The same as well as additional parameters were investigated by the FBG research team. The additional factors were primarily measurements of sunlight penetration into the lakewater, and water chemistry. The latter included dissolved oxygen, 'free' (unbound) carbon dioxide, pH, specific conductivity, chloride ion, and total phosphorus. In addition, the microscopic plants (phytoplanktonic algae) and animals (zooplanktonic invertebrates) were identified. Relative or absolute counts were made.

Dissolved oxygen and temperature were measured with a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at 1-meter intervals throughout the 'upper-lake' (epilimnion) and 'lower-lake'(hypolimnion), and at half-meter intervals through the 'middle-lake' (metalimnion).

Sun- and skylight penetration into the lakewater was measured at 1-meter intervals with a Whitney submersible photometer model LMA-8A, and the relative light intensity was recorded. Measurements were taken on the sunny side of the boat.

Dissolved water color was measured by reading the absorbance of filtered lakewater (0.45 micron) at 440 and 493 nanometers, in a Bausch and Lomb Spectronic 710 with a 15 cm path length.

Water chemistry (alkalinity, 'free' (unbound) carbon dioxide, pH, and specific conductivity and chloride ion) samples were collected with a 3-liter Van Dorn bottle. Alkalinity, free carbon dioxide and pH samples were stored on ice in 250 ml polyethylene bottles, and were analyzed in the field within 1 to 2 hours. Specific conductivity and chloride ion samples were analyzed in the lab, at room temperature.

Alkalinity was determined titrimetrically with 0.002 N sulfuric acid to a final pH of 4.5, with a combination solution of the two dyes bromocresol green and methyl red as the end-point indicator (E.P.A.,1979). Alkalinity is expressed as equivalents of calcium carbonate.

Free (unbound) carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N NaOH to a final pH of 8.3, and with the dye phenolphthalein as the end-point indicator.

Lakewater pH was measured with a digital pH meter (Orion model 231) equipped with a combination probe (Orion Co.).

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB equipped with model B-10 probe (cell constant = 1.0). Correction for sample temperature was made with a standard curve.

Chloride ion concentration was measured with a pH meter (Corning Model 10) equipped with a chloride electrode (Orion model 94-17B) and a double junction reference electrode (Orion Model 90-02). Standard curves were prepared every 2 hours during laboratory analysis.

Samples to be analyzed for phytoplankton and chlorophyll a were collected with a vertical 'tube' sampler. Chlorophyll a samples were filtered, dried and analyzed in the same manner as those collected by lay monitors.

Phytoplankton samples were fixed with iodine (Lugol's Solution) in the field, within 1 to 2 hours after collection. Phytoplankton were counted with a Unitron 'inverted' microscope after settling the samples for 24 hours in counting chambers. At least 200 individual algal 'units' were counted with a modified scan technique (Baker 1973).

Zooplankton density was estimated in samples collected by towing up a plankton net (30 cm diameter, 150 micron porosity) through the oxygenated (>0.5 ppm) portion of the lake. Samples were fixed after collection with a 4% formalin-sucrose solution (Haney and Hall,1973), and subsampled with a 1-ml Hensen-Stemple pipet. Sufficient subsamples were taken to insure that at least 100 microcrustaceans were counted.

RESULTS AND DISCUSSION OF LAY MONITOR DATA

Lay monitor research was conducted separately from Freshwater Biology Group (FBG) research, thus the results are presented separately. Five sampling sites were active on Silver Lake (Fig 1). The lay monitor raw data for 1984 are presented in Appendix A.

Lay monitors collected information on four parameters: water transparency (Secchi disk depth), productivity (chlorophyll a), total phosphorus and thermal stratification. Information on thermal stratification is used mostly to determine the depth of the chlorophyll a sample.

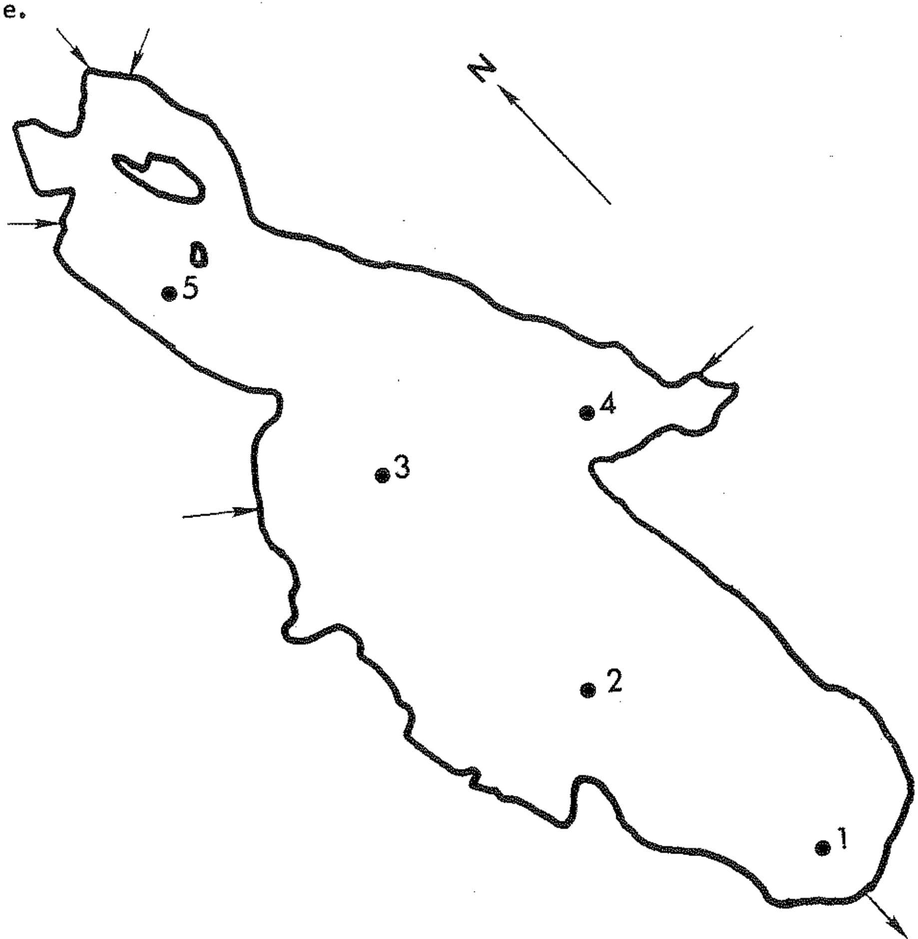

Figure 1. Silver Lake, Town of Madison, New Hampshire.
Outline map and location of 1984 sampling sites.

Secchi Disk Depth (Lay monitor)

The average summer (June-August) Secchi disk depth for all sites was moderate, 5.2 meters, with a range 4.0-6.8 meters. Site 1 had the deepest average summer Secchi disk depth (5.6 meters) (Table 1). Sites 2 and 3 had slightly lower Secchi disk values (5.4 and 5.3 meters respectively). The average at site 5 was 5.1 meters, and at site 4, 5.0 meters (not including one value that bottomed out). Seasonally, the Secchi disk depths were generally lowest in July and August and increased in September. A marked increase in Secchi disk depth was seen on August 30, when all sites had Secchi disk depths above 6.0 meters (except the shallow site 4, where the Secchi disk bottomed out). Secchi disk depths remained above 6.0 meters for the rest of the sampling season.

Chlorophyll a (Lay monitor)

The average summer chlorophyll a concentration for all sites was 1.2 milligrams per cubic meter, with a range of 0.3-3.0 milligrams per cubic meter. Sites 1, 2 and 3 all had average chlorophyll a concentrations of 1.1 milligrams per cubic meter (Table 1). The concentration at site 4 was 1.3 milligrams per cubic meter, and site 5 had the highest chlorophyll a concentration at 1.5 milligrams per cubic meter. Generally, chlorophyll a concentrations were highest in July, and decreased over the rest of the sampling season.

Table 1: Comparison of Secchi disk depth (SDD) and chlorophyll a (chl a) ranges and means for 1984 (BO= bottomed out).

		Range	Mean
Site 1	SDD	4.0-6.8	5.6
	Chl a	0.6-1.6	1.1
Site 2	SDD	4.0-6.7	5.4
	Chl a	0.3-1.9	1.1
Site 3	SDD	4.1-6.3	5.3
	Chl a	0.6-1.9	1.1
Site 4	SDD	4.2-BO	5.0
	Chl a	0.5-2.4	1.3
Site 5	SDD	4.2-6.5	5.1
	Chl a	0.6-3.0	1.5

Total Phosphorus (Lay monitor)

Total phosphorus samples collected by the lay monitors indicate low concentrations of phosphorus in Silver Lake (Table 2). Most of the phosphorus values were below 10 micrograms per liter. One sample, from site 5, revealed a moderate phosphorus concentration (17.7 micrograms per liter), and may indicate higher productivity in that region of the lake. Phosphorus samples were also taken from Cooks Pond Brook (site 6) and Forest Brook (site 7) inlets. Phosphorus concentrations were low, ranging from 2.0-7.9 micrograms per liter, indicating that phosphorus inputs were low at those times.

Table 2. Total phosphorus (TP) data from Silver Lake for 1984. TP=mg/1.

	Jul 16	Aug 8	Aug 17	Sep 5
Site 1	10.6	4.1	3.0	5.6
Site 2	4.5	3.5	1.5	5.3
Site 3	11.2	2.5	0.5	7.4
Site 4	6.9	8.2	4.6	5.8
Site 5	11.7	17.7	5.6	5.8
Site 6	----	----	4.6	6.1
Site 7	----	----	2.0	7.9

Bacteria

Samples for bacteria (coliform and fecal coliform) were collected on September 4, 1984 by Dr. L.W. Slanetz. Tests made by the Department of Microbiology at the University of New Hampshire indicated that the sanitary quality of the water was excellent. No fecal coliform bacteria were found in any of the samples, indicating that there is no contamination from septic tanks in the immediate area of the sites tested (See Appendix B for site locations).

Discussion of Lay Monitor Data

Based on deep Secchi disk depth, low chlorophyll *a* concentration, and low phosphorus concentration, Silver Lake would be classed as oligotrophic.

Secchi disk depths were highly variable, especially during the early part of the testing season. This may be, in part, due to the influence of dissolved water color. The variation is apparently not due solely to chlorophyll *a* concentration, since increases in chlorophyll *a* concentration were not necessarily coupled with decreases in Secchi disk depth, and vice versa.

Generally, Secchi disk depths were lower and chlorophyll a concentrations were higher in the northern part of the lake. Phosphorus data from the inlets indicate low inputs of phosphorus; however, imputs may be greater in the spring and early summer, providing nutrients for algal productivity during the summer.

Compared to 1983, Secchi disk depths were shallower and chlorophyll a concentrations higher in 1984. This may be due to year to year differences in weather. During the early summer, water levels were higher than normal due to above average precipitation. Increased inputs of humic acids, as well as nutients, are likely during that period. Trends in water quality cannot be established from two years of data. Monitoring in the future will be important in determining if a trend is developing.

RESULTS AND DISCUSSION OF FRESHWATER BIOLOGY GROUP DATA

Temperature and Dissolved Oxygen (FBG)

Silver Lake was thermally stratified at both test sites on August 8, the FBG test date. Hypolimnetic oxygen was 6.8-7.0 ppm at both sites. Hypolimnetic temperature was in the range of 8-9 degrees Celsius. These conditions make Silver Lake well-suited for cold-water fish such as lake trout. The limited oxygen depletion in Silver Lake indicates low productivity.

Water Clarity and Dissolved Color (FBG)

The Secchi disk depths measured by the FBG were 5.6 meters at site 2 and 4.5 meters at site 5. These readings are comparable to readings found by lay monitors on the same day.

Dissolved water color was .021 at site 2 and .023 at site 5. These values are relatively low compared to other lakes in the LLMP. Color values found this year were similar to values found in 1983.

Chlorophyll a (FBG)

Chlorophyll a concentrations measured by the FBG were 0.6 micrograms per cubic meter at site 2 and 0.9 micrograms per cubic meter at site 5. These values are comparable to values found by lay monitors on the same day.

Total Phosphorus (FBG)

Total phosphorus is usually the most limiting (least abundant) nutrient in freshwater systems. Increases in algal growth may occur with increases of phosphorus loading. The total phosphorus concentration was low (3.5 micrograms per liter) at site 2 and moderate (17.7 micrograms per liter) at site 5.

Alkalinity, pH, and Free Carbon Dioxide (FBG)

The pH values of near-surface water was in the range of 6.8-6.9. Lower pH values (6.1-6.0) were found in the deeper water (below 10 meters). pH values below 6.0 may limit the growth and distribution of cold-water fish.

Alkalinity was low, averaging 1.9 milligrams calcium carbonate. This value is lower than the average from 1983 (5.7 milligrams calcium carbonate). Additional alkalinity measurements were taken by Dr. Robert Newton and Mr. William Jones, using a slightly different technique than the one used by the FBG. Their measurements ranged from 1.6-5.0 milligrams calcium carbonate per liter. Values found by Dr. Newton in 1983 (3.2-3.5 milligrams per liter) are within the range of values that he found this year. From the alkalinity data from Dr. Newton and Mr. Jones and the FBG, it is not apparent whether the buffering capacity of Silver Lake is decreasing. The data do indicate that the alkalinity is very low and should be monitored closely in the future.

Free carbon dioxide accumulated in the hypolimnion, lowering the pH of the lakewater in that region. The amount of free carbon dioxide accumulating indicates low productivity.

Specific Conductivity and Chloride Ion (FBG)

The specific conductivity in Silver Lake was low, averaging 30.6 micromhos per cm from all depths at both sites. The chloride ion concentation was also low, averaging 0.4 parts per million. These low values indicate that Silver Lake is receiving low inputs of road salt and/or raw sewage.

Phytoplankton (FBG)

The dominant phytoplankton groups in Silver Lake on August 8 included the Chrysophytes (Ochromonas), blue-green bacteria (Merismopedia) and the Chlorophytes (Polytoma). At site 5 the Chryptomonads (Chryptomonas) and the Dinoflagellates were also of numerical importance. The density of phytoplankton was higher at site 5 (2092 cells per milliliter) than at site 2 (832 cells per milliliter), indicating that site 5 is a more productive area in the lake. The presence of blue-green bacteria usually indicates more eutrophic conditions, however Merismopedia appears to be more general in its affinities than many of the other blue-green bacteria.

Zooplankton (FBG)

The density of herbivorous crustacean zooplanton was low (5 animals per liter) at site 2 and moderate (18 animals per liter) at site 5. The dominant group at both sites was calanoid copepods. The higher number of zooplankton at site 5 reflects the higher productivity at that site.

REFERENCES

Baker, A. L. 1973. Microstratification of phytoplankton in selected Minnesota lakes. Ph. D. thesis, University of Minnesota.

Brooks, J. L. and E. S. Deevey, Jr. 1963. New England. In: D. G. Frey (ed.), Limnology in North America. University of Wisconsin Press, Madison.

Carlson, R. E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22:361-379.

Davis, R. B., J. H. Bailey, M. Scott, G. Hunt and S. A. Norton. 1978. Descriptive and comparative studies of Maine lakes. Technical bulletin 88. Life Sciences and Agr. Exp. Station, University of Maine.

Edmondson, W. T. 1937. Food conditions in some New Hampshire lakes. In: Biological survey of the Androscoggin, Saco and coastal watersheds. (Report of E. E. Hoover.) New Hampshire Fish and Game Commission, Concord, New Hampshire.

Gallup, D. N. 1969. Zooplankton distributions and zooplankton-phytoplankton relationships in a mesotrophic lake. Ph.D. Thesis, University of New Hampshire.

Forsberg, C. and S.-O. Ryding. 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste-receiving lakes. Arch. Hydrobiol. 89:189-207.

Haney, J. F. and D. J. Hall. 1973. Sugar-coated Daphnia: a preservation technique for Cladocera. Limnol. Oceanogr. 18:331-333.

Hoover, E. E. 1936. Preliminary biological survey of some New Hampshire Lakes. Survey report no. 1. New Hampshire Fish and Game Department, Concord, New Hampshire.

Hoover, E. E. 1937. Biological survey of the Androscoggin, Saco and coastal watersheds. Survey report no. 2. New Hampshire Fish and Game Department, Concord, New Hampshire.

Hoover, E. E. 1938. Biological survey of the Merrimack Watershed. Survey report no. 3. New Hampshire Fish and Game Department, Concord, New Hampsire.

Hutchinson, G. E. 1967. A treatise on limnology, vol. 2. John Wiley and Sons, New York.

Hutchinson, G. E. 1973. Eutrophication. American Scientist 61:269-279.

Likens, G. E. 1975. Primary productivity of inland aquatic ecosystems. In: H. Lieth and R. H. Whittaker (eds.), Primary productivity of the biosphere. Springer-Verlag, New York.

Lind, O. T. 1979. Handbook of common methods in limnology. C. V. Mosby, St. Louis.

Lorenzen, M. W. 1980. Use of chlorophyll-Secchi disk relationships. Limnol. Oceanogr. 25:371-372.

Newell, A. E. 1970. Biological survey of the lakes and ponds in Cheshire, Hillsborough and Rockingham Counties. Survey report no. 8c. New Hampshire Fish and Game Department, Concord, New Hampshire.

Newell, A. E. 1972. Biological survey of the lakes and ponds in Coos, Grafton and Carroll Counties. Survey report no. 8a. New Hampshire Fish and Game Department, Concord, New Hampshire.

Newell, A. E. 1977. Biological survey of the lakes and ponds in Sullivan, Merrimack, Belknap and Strafford Counties. Survey report no. 8b. New Hampshire Fish and Game Department, Concord, New Hampshire.

New Hampshire Water Supply and Pollution Control Commission 1981. Classification and priority listing of New Hampshire Lakes. Staff report no. 121. Concord, New Hampshire.

Utermohl, H. 1958. Improvements in the quantitative methods of phytoplankton study. Mitt. int. Ver. Limnol. 9:1-25.

Warfel, H. E. 1939. Biological survey of the Connecticut Watershed. Survey report no. 4. New Hampshire Fish and Game Department, Concord, New Hampshire.

U.S. Environmental Protection Agency. 1979. A manual of methods for chemical analysis of water and wastes. Office of Technology Transfer, Cincinnati. PA-600/4-79-020.

APPENDIX A

LLMP 1984 -- Lay Monitor Data: Silver (Madison) Jan-17-85

16:58.19

Date	Lake	Site	SDD	Chl
Jun-07-84	Silver (Madison	1 South	5.50	1.33
Jun-16-84	Silver (Madison	1 South	5.50	1.43
Jun-21-84	Silver (Madison	1 South	5.00	1.21
Jun-28-84	Silver (Madison	1 South	5.70	1.57
Jul-05-84	Silver (Madison	1 South	5.70	1.28
Jul-13-84	Silver (Madison	1 South	4.50	1.57
Jul-19-84	Silver (Madison	1 South	6.30	1.14
Jul-26-84	Silver (Madison	1 South	4.25	.71
Aug-02-84	Silver (Madison	1 South	6.80	1.07
Aug-08-84	Silver (Madison	1 South	5.70	.64
Aug-15-84	Silver (Madison	1 South	5.70	.71
Aug-24-84	Silver (Madison	1 South	5.20	1.07
Aug-30-84	Silver (Madison	1 South	6.30	.86
Sep-05-84	Silver (Madison	1 South	6.00	.93
Sep-22-84	Silver (Madison	1 South	6.50	.71
Oct-12-84	Silver (Madison	1 South	6.50	---

Jun-07-84	Silver	(Madison	2 Deep	5.90	---
Jun-16-84	Silver	(Madison	2 Deep	4.50	.93
Jun-21-84	Silver	(Madison	2 Deep	5.30	1.28
Jun-28-84	Silver	(Madison	2 Deep	6.30	1.14
Jul-05-84	Silver	(Madison	2 Deep	5.20	1.43
Jul-13-84	Silver	(Madison	2 Deep	4.00	1.86
Jul-19-84	Silver	(Madison	2 Deep	5.80	1.43
Jul-26-84	Silver	(Madison	2 Deep	4.50	1.00
Aug-02-84	Silver	(Madison	2 Deep	6.70	1.14
Aug-08-84	Silver	(Madison	2 Deep	5.60	.64
Aug-15-84	Silver	(Madison	2 Deep	5.00	.29
Aug-24-84	Silver	(Madison	2 Deep	4.80	.93
Aug-30-84	Silver	(Madison	2 Deep	6.40	.71
Sep-05-84	Silver	(Madison	2 Deep	6.40	.29
Sep-22-84	Silver	(Madison	2 Deep	6.60	.78
Oct-12-84	Silver	(Madison	2 Deep	6.20	---

Jun-07-84	Silver	(Madison	3 Center	4.10	---
Jun-16-84	Silver	(Madison	3 Center	5.50	1.00
Jun-21-84	Silver	(Madison	3 Center	5.00	1.00
Jun-28-84	Silver	(Madison	3 Center	6.30	1.36
Jul-05-84	Silver	(Madison	3 Center	4.80	1.36
Jul-13-84	Silver	(Madison	3 Center	4.70	1.43
Jul-19-84	Silver	(Madison	3 Center	5.50	1.43
Jul-26-84	Silver	(Madison	3 Center	4.50	.78
Aug-02-84	Silver	(Madison	3 Center	6.30	1.86
Aug-08-84	Silver	(Madison	3 Center	5.50	.78

Aug-15-84	Silver	(Madison	3 Center	5.30	.86
Aug-24-84	Silver	(Madison	3 Center	5.50	.93
Aug-30-84	Silver	(Madison	3 Center	6.30	.57
Sep-05-84	Silver	(Madison	3 Center	6.80	.78
Sep-22-84	Silver	(Madison	3 Center	6.00	.57
Oct-12-84	Silver	(Madison	3 Center	6.60	---
Jun-07-84	Silver	(Madison	4 East	4.50	---
Jun-16-84	Silver	(Madison	4 East	5.00	1.12
Jun-21-84	Silver	(Madison	4 East	5.30	1.21
Jun-28-84	Silver	(Madison	4 East	4.80	1.71
Jul-05-84	Silver	(Madison	4 East	---	1.43
Jul-13-84	Silver	(Madison	4 East	4.20	2.36
Jul-19-84	Silver	(Madison	4 East	4.30	1.86
Jul-26-84	Silver	(Madison	4 East	5.00	1.21
Aug-02-84	Silver	(Madison	4 East	5.30	1.57
Aug-08-84	Silver	(Madison	4 East	5.30	1.14
Aug-15-84	Silver	(Madison	4 East	5.00	.64
Aug-24-84	Silver	(Madison	4 East	5.00	.86
Aug-30-84	Silver	(Madison	4 East	5.50	.50
Sep-05-84	Silver	(Madison	4 East	---	.93
Sep-22-84	Silver	(Madison	4 East	---	.71
Oct-12-84	Silver	(Madison	4 East	---	---
Jun-07-84	Silver	(Madison	5 North	4.50	---
Jun-16-84	Silver	(Madison	5 North	6.00	1.21

Jun-21-84	Silver	(Madison	5 North	5.10	1.07
Jun-28-84	Silver	(Madison	5 North	5.30	1.14
Jul-05-84	Silver	(Madison	5 North	4.80	1.14
Jul-13-84	Silver	(Madison	5 North	4.20	2.14
Jul-19-84	Silver	(Madison	5 North	4.30	2.43
Jul-26-84	Silver	(Madison	5 North	4.50	1.64
Aug-02-84	Silver	(Madison	5 North	5.30	3.00
Aug-08-84	Silver	(Madison	5 North	4.50	.93
Aug-15-84	Silver	(Madison	5 North	5.20	.64
Aug-24-84	Silver	(Madison	5 North	4.80	1.64
Aug-30-84	Silver	(Madison	5 North	6.50	.64
Sep-05-84	Silver	(Madison	5 North	5.80	1.14
Sep-22-84	Silver	(Madison	5 North	6.00	.78
Oct-12-84	Silver	(Madison	5 North	6.60	---

>>> END OF LIST <<<

APPENDIX C
Bacteria Sampling Data

Site Number	Location	Coliform Bacteria per 100 ml of water Total	Fecal
1	300 ft. from dam	4	0
2	200 ft. east from Allegro Pines Pt.	0	0
3	200 ft. west of Hurricane Pt.	0	0
4	Middle of cove - east from Moon Is.	9	0
5	200 ft. west of Bimba Is.	0	0
6	Public beach - end of lake	0	0
7	100 ft. from shore - midway East Shore Dr.	4	0
8	100 ft. from Allegro Pines Pt.	0	0
9	100 ft from shore - midway Winter Rd.	0	0
10	Public beach - head of lake	0	0
11	Public beach - Route 41	0	0

Samples collected: 4-Sept-84
Tests completed: 11-Sept-84